BREEDING STATUS OF THE YELLOW-BILLED CUCKOO IN THE SOUTH FORK KERN RIVER VALLEY, KERN COUNTY, CALIFORNIA: SUMMARY REPORT 1985 - 1996

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INTRODUCTION

Over the past 12 years (1985-1996) we have been conducting a study of the breeding ecology of the Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*) in the South Fork Kern River Valley. Each year we have conducted surveys to determine abundance and distribution of nesting pairs and to monitor nest success. In most years, we have also observed nesting behavior to obtain information on food supplies as they related to nesting success.

The results from 1985 to 1991 have been presented in reports to The Nature Conservancy, California Department of Fish and Game, and US Forest Service (Laymon and Halterman 1985 and 1986; Laymon, Halterman and Whitfield 1987; Laymon and Whitfield 1988; Laymon, Halterman and Gallion 1989; Laymon, Halterman, Launer and Murphy 1990; Laymon 1991; and Laymon, Williams, and Halterman 1993). The research objectives for the project were to: (1) census the yearly breeding population; (2) determine site tenacity through banding adults and young; (3) determine yearly nesting success; (4) determine nesting habitat use; and (5) develop and test a habitat relationships model. In this report we summarize the results of 12 years of data gathered from 1985 to 1996.

STUDY AREA

The study area consists of approximately 2600 acres of riparian habitat along the South Fork of the Kern River from Lake Isabella upstream to Onyx Ranch, a distance of six miles. The major land owners are U.S. Forest Service (South Fork Wildlife Area) and The Nature Conservancy (Kern River Preserve). In the past the South Fork Wildlife Area was owned and managed by U.S. Army Corps of Engineers and California Department of Fish and Game. This area was transferred to the U.S. Forest Service in spring 1991. Management and ownership of the Kern River Preserve is currently (1997) being transferred from The Nature Conservancy to Audubon California.

The elevation of the study area ranges from 2500 to 2680 feet. The habitat is forest and woodland consisting predominantly of three tree species: (1) red willow (*Salix laevigata*), (2) Goodding's black willow (*Salix gooddingii*); and (3) Fremont cottonwood (*Populus fremontii*). Non-forested areas of mule fat (*Baccharis salicifolia*), stinging nettle (*Urtica holosericea*), and meadow intersperse the forest.

The extent of riparian habitat in the study area has varied greatly over the past 12 years. Approximately 320 acres of habitat has been planted on riparian restoration sites on the Kern River preserve. The first planting was done in 1986 and the most recent planting was done in 1994. Additional riparian habitat (approaching 2000 acres in extent) germinated naturally in the South Fork Wildlife Area and in the Isabella Reservoir Draw-Down Zone (west of Patterson Lane) as the result of initial inundation in 1986 and the subsequent lake draw-down from 1987 through 1992.

METHODS

We surveyed breeding pairs of cuckoos using two methods: (1) repeated survey transects; and (2) location of nest sites. We conducted surveys using a "kowlp" call tape recording played on a 2-speaker portable tape recorder. We made survey stops every 150 to 200 yards. We used ten calls, spaced 1 minute apart, to elicit responses at each stop. The recording could be heard at a minimum distance of 200 yards under all field conditions except high winds when surveys were not conducted. We plotted the cuckoo's locations on 1:24000 scale maps and aerial photos. These maps were used to determine areas of activity. When areas of activity of pairs were located, we began to search for the nest. We located nests by watching activity patterns, particularly foraging and food carrying.

At several nests, in most years, we observed adult nest tending behavior and monitored food being carried to nests and fed to young. We counted the number of feedings for each young, recorded the species of prey, and the size of prey.

We banded, weighed, and measured young cuckoos before they left their nests. We captured and banded adult cuckoos by setting up mist nets near nests when the young were about to fledge. Each bird received a U.S. Fish and Wildlife Service band and color bands. Nesting success was determined by the number of young that fledged successfully. Egg laying dates, hatch dates, and fledge dates were extrapolated by comparing measurements to those of young of known ages and by using an average 11 day incubation period and seven day nestling period.

We surveyed the habitat and vegetation structure at nest sites on 11.3 m radius circular plots (0.1 acre). On all plots we collected data on: (1) percent canopy closure; (2) foliage volume; (3) tree density; (4) Diameter at breast height - DBH - of all trees $\geq$ 6 cm in diameter; (5) percent cover of shrub layer; (6) percent of ground cover; (7) percent of foliage cover above the nest; (8) distance from nest to foliage above; (9 and 10) distance from nest to woodland edge and to water; and (11 and 12) height and DBH of nest tree. We also conducted vegetation surveys at 80 random sites in the South Fork Wildlife Area and at 160 random sites on the Kern River Preserve.

RESULTS

Population Size and Distribution

The nesting population of Yellow-billed Cuckoos has fluctuated greatly over the course of this study (Table 1). The 12 year study was split into two 6-year periods, with 1991 as the beginning of the recent period. This split marks the beginning of both the maturing of habitat on the restoration sites at the Kern River Preserve and on the natural regeneration areas in the South Fork Wildlife Area. For the first six years of the study (1985 to 1990) the number of cuckoo pairs varied from a low of 2 pairs (1990) to a high of 9 pairs (1985 & 1986) and averaged 5.3 pairs (SD=3.14, 2SE=2.56). For the next six years of the study (1991 to 1996) the number of cuckoo pairs varied from a low of 12 (1991) to a high of 24 pairs (1992) and averaged 16.8 pairs (SD=4.62, 2SE=3.77). This difference, using a Mann-Whitney U test, was statistically significant ($U=0.0$, $Z=2.88$, $p=0.004$).

Most of the increase in population was in the South Fork Wildlife Area where the average of the first six years (1985 - 1990) was 2.0 pairs and of the next six years (1991 - 1996) was 8.0 pairs. This difference was statistically significant ($U=1.0$, $Z=2.72$, $p=0.006$). The number of cuckoo pairs on the Kern River Preserve was also higher during the latter six years (3.3 pairs, 1985-1990 vs. 6.7 pairs, 1991-1996), but the difference was not statistically significant ($U=8.0$, $Z=1.60$, $p=0.11$).

The year to year shift in location of cuckoo pairs (see Figures 1-9) may be related to several factors including food abundance, amount of rainfall, level of lake inundation, and amount of available habitat. Because of the scope of the study and difficulty in detecting cuckoo prey, we are not able to directly measure food abundance.

Yearly rainfall data for Isabella Reservoir is kept by the Army Corp of Engineers at Isabella Dam. Regression analysis showed that only the number of pairs of cuckoos on the Kern River Preserve was significantly related to rainfall ($r^2=0.53$, $p=0.004$) with higher numbers in wetter years. Much of this relationship is caused by cuckoos being forced out of the South Fork Wildlife Area during years of high water.

The maximum lake level for each year is also measured by the Army Corp of Engineers. Regression analysis again showed that only the number of pairs of cuckoos on the Kern River Preserve was significantly related to lake level ($r^2=0.83$, $p<0.0001$), with higher lake levels being related to more cuckoos in that area. This relationship is caused by cuckoos being forced out of the South Fork Wildlife Area during years of high water.

The extent of available habitat appears to be the major factor governing the population of cuckoos. Extent of available habitat is somewhat related to maximum lake level, but is also related to an absolute increase in habitat over time as a result of restoration and natural regeneration. In 1985, we suggested that a population of 9 pairs of cuckoos was the maximum that could occur with the habitat available at that time (Laymon and Halterman 1985). We recommended to The Nature Conservancy that an experimental riparian habitat restoration program be initiated to expand the habitat base and ultimately the cuckoo population. This restoration program has established approximately 125 ha (310 acres) of habitat on the Kern River Preserve, all of which was being used by cuckoos by the summer of 1996. An additional 510 ha (1275 acres) of habitat was established by natural

regeneration during the drought in the South Fork Wildlife Area and the Isabella Reservoir Draw-Down Zone between 1987 and 1992. Much of this habitat was inundated in 1993 and again in 1995 and 1996, and has been unavailable to nesting cuckoos. The available habitat in the South Fork Wildlife Area has varied from a low of 292 ha (730 acres) in 1985 and 1986 to a high of 854 ha (2135 acres) in 1992 (Table 2). On the Kern River Preserve a low of 212 ha (530 acres) of habitat was available from 1985 to 1988. Gradually as the restoration sites became suitable, the amount of habitat has grown to 347 ha (868 acres). In the South Fork Wildlife Area, 80 ha (200 acres) of habitat was available in 1985 and 1986. This grew to 380 ha (950 acres) in 1991 and 1992 and has decreased to 180 ha (450 acres) in 1995 and 1996 due to inundation. In the Isabella Reservoir Draw-Down Zone 100 ha (250 acres) was available in 1991 and 200 ha (500 acres was available in 1992. No habitat has been available in this area in any subsequent years, due to inundation (Table 2).

The number of pairs of cuckoos in the South Fork Kern Valley is closely related to the amount of available habitat. Using a regression analysis, more than half of the variation in cuckoo numbers (51.3%) was explained by the amount of available habitat ($r^2=0.51$, $p=0.009$). This pattern held for the Kern River Preserve ($r^2=0.44$, $p=0.02$), the South Fork Wildlife Area ($r^2=0.59$, $p=0.003$), and the Isabella Reservoir Draw-Down Zone ($r^2=0.97$, $p<0.00001$).

Nesting Success

During the course of the study we found and monitored 95 Yellow-billed Cuckoo nests (Table 4a & 4b). The number of nests located varied from a low of one in 1990 to a high of 23 in 1992. Of the 94 nests for which we have nesting outcome, 87% (82) were successful at fledging at least one young and 13% (12) failed to fledge any young (Table 4a). The nesting success ranged from a high of 100% during 7 years to a low of 64% during 1996 (Table 3). Nesting success during 1996 was significantly lower than the combination of all other years ($X^2=6.23$, $p=0.01$). No other single year had nesting success that was significantly different from the combination of all other years.

The number of eggs per nest averaged 2.95 over the 92 nests (Table 4a). The minimum number of eggs for completed nests was two and the maximum, laid by one female, was five. One nest (1.1%) had one egg, 20 nests (20.2%) had two eggs, 57 (60.6%) had three eggs, 11 (11.7%) had four eggs, and 2 (2.1%) had five eggs. The only six egg clutch was laid by two females, four by the dominant female and two by a secondary female that had her first nest destroyed after her first egg was laid. The mean clutch size was highest in 1992 (3.35, $n=23$) and lowest in 1989 (2.33, $n=3$). Clutch size was compared between all years using a t-test. Only during 1995 when the mean clutch size was 2.5 eggs, was clutch size significantly different than any other years (1995 vs. 1994, mean clutch size 1994 = 3.0 eggs, $t=2.22$, $p=0.03$; and 1995 vs. 1992, mean clutch size 1992 = 3.35, $t=2.22$, $p=0.03$).

The number of young hatched averaged 2.53 young per nest over the 92 nests, for an average loss of 0.42 eggs per nest. A total of 269 eggs in 92 nests were laid and 233 young in 88 nests hatched for a 87% egg to chick success rate. Four nests failed during the

incubation stage (33% of the unsuccessful nests). The minimum number of young hatched in the 88 nests that successfully hatched was one (4 nests, 4.4%). The maximum number of young hatched was 4 (6 nests, 7.8%). Two young were hatched in 31 nests (33.3%) and three young were hatched in 46 nests (54.4%). One nest attended by two females hatched 5 of 6 eggs. The highest mean number of hatchlings per nest was 2.87 (n=23, SD=1.14) in 1992 and the lowest was 2.0 (n=3, SD=1.0) in 1988. No pairwise comparisons across years of number of young hatched was significant.

The number of young fledged averaged 2.14 young per nest over the 93 nests (Table 4a), for an average loss of 0.39 young per nest. A total of 269 eggs were laid and 199 young fledged for a 74% egg to fledgling success rate. The hatching to fledgling success rate was 86% (199 fledglings from 233 hatchlings). Eight nests failed during the nestling stage (67% of the unsuccessful nests). The minimum number of young fledged in the 81 successful nests was one (8 nests, 9.8%). The maximum number of young fledged was 4 (5 nests, 6.1%). Two young were fledged in 33 nests (41.5%) and three young were fledged in 35 nests (42.7%). The highest yearly mean number of fledglings per nest was 2.6 (n=8, SD=0.74) in 1985 and the lowest was 1.25 (n=4, SD=0.95) in 1986. When mean number of young fledged was compared across years, 1996 fledgling rate of 1.3 young per nest was significantly lower than 1994 (mean = 2.45, t=3.01, p=0.007) ; 1993 (mean = 2.3, t=2.47, p=0.02; 1992 (mean = 2.39, t=2.50, p=0.02); and 1985 (mean = 2.63, t=2.99, p=0.008). The only other significant differences in fledgling rate were between 1994 (mean = 2.45) and 1986 (mean = 1.25) (t=2.72, p=0.02), and 1985 (mean = 2.63) and 1986 (mean = 1.25) (t=2.76, p=0.02).

Yellow-billed Cuckoos hatch their eggs asynchronously by beginning incubation when the first egg is laid. This strategy is thought to be used by species which rely on a cyclical or undependable food supply. It is thought that asynchronous hatching leads to a increased chance that at least one (the oldest) young will fledge if food becomes scarce. In cuckoos the brood reduction can occur either during the incubation or nestling stage. Thirty-four of the 95 nests (35.8%) showed evidence of brood reduction. Of the 75 eggs that were laid but did not fledge, 34 (45.3%) were from nests that failed. Of the other 41 eggs (54.7%) that did not produce fledged young, 26 eggs did not hatch and 15 hatched but did not fledge. Eggs did not hatch when parents stopped incubation before the youngest egg hatched, probably because the parents had insufficient food to feed the older young while continuing incubation and the parents were forced to stop incubation before the youngest egg hatched. The 15 young that hatched but did not fledge either died in the nest (possible but not observed) or were removed from the nest alive by a parent (only the dominant male has been observed doing this) when food supply dropped.

In 1991 we first determined that double brooding occurred. Again in 1992 we found many instances of double brooding and several occurrences of triple brooding. In 1992, of the 17 pairs for which we located at least one nest, six pairs double brooded (both nests found for 2 pairs) and three pairs triple brooded (all three nests found for two pairs), several successfully raising all three broods. In some years, little or no double and triple brooding occurs. For example in 1996, of the 12 pairs that were tracked, only one pair attempted and successfully reared a second brood. In 1994 and 1995 no evidence of double brooding was

found for pairs that successfully raised their first broods. No occurrences of double or triple brooding by Yellow-billed Cuckoos have been noted in the literature.

The first egg date is important in determining both the chance of nesting success and the opportunity of double brooding. Nesting success for nests started early in the season (prior to 1 July) (n=27 nests) were slightly, though not significantly, less successful than nests started between 1 July and 16 July (X^2=0.76, p=0.38) (n=37 nests). Nests started after 16 July were however less successful than nests started in mid-season (X^2=6.42, p=0.01) (n=26 nests). Regression analysis showed a significant relationship between both number of young fledged (r^2=0.07, p=0.01) and nest success (r^2=0.06, p=0.02) when compared to first egg date.

Food Resources

During eight of the 12 years of the study, we monitored nests to determine what types of food was being fed to the young. Yellow-billed Cuckoos feed their young whole prey items and generally hold them in view for a few seconds before the young swallow the food item. We were able to identify 2420 prey items being fed to the young cuckoos in 30 nests during the course of the study. In addition to identifying the prey and determining the size of the food item in relationship to the size of the cuckoo's bill, we were able to record the time it took for a cuckoo to leave the nest and return with a food item of a certain type . The primary food items were green caterpillars (primarily sphinx moth larvae) at 44.9% of diet (range = 20.0% to 64.5%), katydids at 21.8% (range = 5.3% to 43.0%), tree frogs at 23.8% (range = 3.7% to 42.7%), and grasshoppers at 8.7% (range = 4.4% to 17.1%) (Table 10). The number of eggs laid was directly proportional to the percent of katydids fed to the young (r^2=0.55, p=0.04) and inversely proportional to the percent of green caterpillars fed to the young (r^2=0.51, p=0.05).

The size of the prey items, as measured by Yellow-billed Cuckoo bill lengths varied much less than either proportion of different prey items in the diet or time that it took to catch prey and return to the nest (Table 11). Neither number of eggs or number of young were correlated to prey size.

Capture time varied between both prey type and year (Table 12). Green caterpillars took the longest time to capture averaging 43.9 min. (range = 21.3 min. to 82.4 min.). Katydid capture time averaged 33.8 minutes (range = 12.0 min. to 60.8 min.). Tree frog capture time averaged 29.0 minutes (range = 13.0 min. to 41.7 min.). The capture time of caterpillars (r^2=0.46, p=0.06), katydids (r^2=0.42, p=0.08), and all food (r^2=0.47, p=0.06) was nearly significantly correlated to the average total number of young produced by a pair in a year.

Nest Site Characteristics

We conducted vegetation surveys at 95 nests. All of the nests were in willows with the exception of one that was in a mistletoe clump in a fremont cottonwood. Of the 94 nests

in willows, 54 (57.4%) were in Gooding's black willow and 40 (42.6%) were in red willow. The average nest tree height was 9.4 m (SD=3.5) with the shortest nest tree at 2.5 m and the tallest at 17.8 m. The DBH of the average nest tree was 25.4 cm (SD=18.7) and ranged from 3 cm to 90 cm.

The average nest height was 4.8 m (SD=3.0) and ranged from a low of 1.3 m to a high of 13 m. Most nests (66, 69.5%) were place on horizontal branches, while 13 (13.7%) were placed in tree crotches and 16 (16.8%) were placed in vertical forks. Nests were placed closer to the tip of the branches than to the trunk of the tree. On average nests were placed 1.4 m (SD=0.6; range 0 m to 3.0 m) from the tip of the branch in a clump of dense foliage. On average nests were placed 2.7 m from the trunk (SD=3.1; range = 0 m to 12.0 m).

Most nests (67, 72%) were placed on the east side of the nest tree. There was a greater proportion of east facing nests than would be expected by chance (X^2=9.45, p=0.002). Estimated cover above the nest averaged 93.4% (SD=15.1) and ranged from 0% to 100%. Average canopy closure on the nest site vegetation sampling plot averaged 74.1% (SD=15.6) and ranged from 16.5% to 98% (Table 5). At the center of the plot under the nest the canopy closure averaged 96.8% (SD=7.3) and ranged from 63% to 100%. At 5 m from the nest the canopy closure averaged 75.1% (SD=18.1) and ranged from 17.5 to 100% and at 10 m from the nest the canopy closure averaged 63.8% (SD=26.1) and ranged from 0% to 100%.

Comparison of Vegetation at Nests and Random Points

Because the forest structure on the South Fork Wildlife Area and the Kern River Preserve differed significantly for almost all factors that were measured (Table 6), we compared vegetation structure at nests in each of the two areas with random points in those areas. We compared vegetation structure for 38 nests found on the Kern River Preserve with structure at 160 random points on the Preserve (Table 7). Cuckoos used nest sites that had significantly greater canopy closure, percent bare ground, percent forb cover, tree density, willow density, and foliage volume than was found in the forest at random. The nest sites had significantly less ground cover, grass cover, shrub cover, and smaller diameter trees than were found at random in the old forest.

We then compared vegetation structure for 49 nests in the South Fork Wildlife Area with structure for 80 random points (Table 8). Cuckoos used nest sites that had significantly greater canopy closure, percent bare ground, percent forb cover, percent shrub cover, tree density, willow density, cottonwood density, foliage volume, basal area, and mean tree height than was found in the forest at random. The nest sites had significantly less ground cover and grass cover than was found at random in the old forest.

We also compared vegetation structure for the 49 cuckoo nests sites in the South Fork Wildlife Area with the structure at the 38 nests on the Kern River Preserve (Table 9). The South Fork Wildlife Area nests had significantly more trees, willows, and Gooding's willows. The Kern River Preserve nests had significantly more foliage volume and larger

average tree diameter. No other vegetation structure variable was significantly different for cuckoo nests between the two areas.

Wildlife-Habitat Relationships

Nest sites were assigned to Wildlife-habitat Relationship (WHR) categories based on canopy closure and mean quadratic DBH (Mayer and Laudenslayer 1988). In the WHR system, canopy cover from 10% to 24% is sparse (S), from 25% to 39% is poor (P), from 40% to 59% is moderate (M), and 60% or greater is dense (D). There are also four categories of mean quadratic DBH. Mean DBH from 2.5 cm to 15.0 cm is sapling (2), from 15.5 cm to 27.5 cm is pole tree (3), from 28.0 cm to 60 cm is small tree (4), and greater than 60 cm is medium/large tree (5).

The nests were almost entirely in the D canopy closure category (84.7% of 85 nest sites) with a few in the M category (14.1%), none in the P category and only one in the S category (1.2%). One nest site was in the 5 DBH category (1.2%) and the rest were divided equally between the other 2 (32.9%), 3 (30.6%), and 4 (35.3%) categories. The combined WHR forest types for nest sites were: 2M 7.1%, 2D 25.9%, 3S 1.2%, 3M 3.5%, 3D 25.9%, 4M 3.5%, 4D 31.8%, and 5D 1.2%.

Random sites were quite different than the nest sites. In the South Fork Wildlife Area, 25% of the random sites had less than 10% canopy cover and were therefore not considered forest by the WHR system. Most of the remaining sites (40%) were in size class 2, 23.8% were in size class 3, 11.3% were in size class 4, and none were in size class 5. Most sites were classed as S canopy cover (22.5%), while 21.3% were P, 16.3% were M and 15% were dense. The largest WHR classes were 2S (11.3%), 2P (8.8%), 2D (13.8%), and 3P (10.0%).

Random sites on the Kern River Preserve were also different than the nest sites as well as being different from the South Fork Wildlife Area random sites. On the preserve, 13.8% of the sites had less than 10% canopy cover and were therefore not considered forest by the WHR system. Most of the remaining sites (38.1%) were in size class 5, 30.6% were in size class 4, 10.0% were in size class 3, and 7.5% were in size class 2. Most sites were classed as D canopy cover (50.6%), while 11.3% were M, 13.8% were P and 7.5% were S. The largest WHR classes were 5D (24.4%) and 4D (21.3%).

DISCUSSION AND RECOMMENDATIONS

Population Size and Distribution

The population of Yellow-billed Cuckoos has increased significantly over the past 12 years. This is caused by an overall increase in suitable habitat for the species. This increase has been a result of a combination of active and passive habitat restoration in the South Fork Kern River Valley. The available habitat on the Kern River Preserve increased from 212 ha to 347 ha, a 64% increase, between 1985 and 1996. The increase in habitat on the Preserve was almost entirely the result of active restoration efforts.

In the South Fork Wildlife Area the available habitat has more than doubled even during high water years. At the peak habitat availability, the amount of habitat in this area increased from 80 ha in 1985 to 380 ha in 1991 and 1992. Habitat (up to 200 ha) was also available in the Isabella Reservoir Drawdown Zone during 1991 and 1992, but has not been available since. The increase in habitat on the South Fork Wildlife Area and the Isabella Reservoir Draw-Down Zone was because of natural regeneration followed by several years of drought which allowed the seedlings to become established.

In this study we have found the number of pairs of nesting cuckoos to be tightly linked to the amount of available habitat, indicating that Yellow-billed Cuckoo populations are habitat limited. In a report to The Nature Conservancy in 1987 (Laymon 1987) at the beginning of the restoration effort, we predicted that this would be the case. We predicted that with restoration of all available sites on the preserve, the population of cuckoos in the Kern Valley would increase from 10 to 26 pairs. In retrospect we were somewhat overly optimistic about the effects of restoration. The population did increase to near the goal of 25 pairs in 1992, when many pairs nested in the young willows of the South Fork Wildlife Area and the Isabella Reservoir Draw-down Zone, but with the return of the high water and the loss of over 300 ha of available habitat in 1993, the population shrunk to 19 pairs and then to 13 pairs in 1995. To date, without the intermittent habitat in Isabella Reservoir, the cuckoo population has increased from a maximum of nine pairs to a maximum of 14 pairs.

On the Kern River Preserve, additional habitat restoration of up to 40 ha is still possible, but this requires solving access and other problems before it can take place. In order to replace the 300 ha of intermittent habitat in Isabella Reservoir, additional land acquisition and restoration is needed out of the reservoir. We recommend a minimum of 400 ha of land acquisition and restoration to provide habitat for a minimum population of 25 pairs of cuckoos in the South Fork Kern River Valley population.

Our 1987 prediction that widening the available habitat would provide more benefit than creating linear habitat of the same area has also proved to be true. From 1985 to 1990 all pairs were strung out linearly along the South Fork Kern River (Figures 1-3). Beginning in 1991 as the flood plain forest was broadened, a trend towards less linearity and more clumping of territories has been observed (Figures 4-9). This leads to more pairs being packed into a smaller area.

Nesting Success and Food Resources

Yellow-billed Cuckoos during this study had extremely high nesting success. Eighty-seven percent of the nests that we monitored successfully fledged at least one young. This success rate is much higher than is expected for an open-cup nesting bird. Most studies show success rates of 50% or lower. There are several possible explanations for this high nesting success. Yellow-billed Cuckoos, at least in years of adequate or better food resources, rarely leave their nests unattended. One adult incubates or broods while the other forages. Feeding the young large prey items also means that fewer trips to the nest are required thus providing greater protection from predators. A cuckoo pair with two young in the nest only feed 20 times per day. Many other bird species feed 20 times or more in an hour. In addition, the nests are generally well hidden in the foliage, making them difficult for predators to locate. Lastly, cuckoos nest later than most other birds and nest predators, for the most part, may have switched to other food sources than eggs and nestlings by the height of the cuckoo nesting season.

Yellow-billed Cuckoos use brood reduction of both eggs and young to enhance their reproductive success. In years of moderate food availability, more eggs are laid than can be raised and generally one, and sometimes more eggs or young do not hatch or fledge. In the egg stage, eggs simply do not hatch because incubation of the youngest eggs is terminated so sufficient food can be brought to the already hatched young. In the nestling stage, apparently, the incessant begging behavior of the hungry young triggers the adult male to remove the youngest nestling from the nest while it is still alive. In many other species a food stressed nest would fail or be found by predators. In cuckoos the number of young is limited by the adult male and the nest then generally succeeds.

The occurrence of double and triple brooding of Yellow-billed Cuckoos is significant. This indicates that the reproductive potential of the species is much greater than was previously believed. Instead of a pair of cuckoos being able to produce three to four young per season, they can actually produce up to ten young per season, if sufficient food resources are available. This is very important in constructing population models for the species. However, at this site we found that cuckoos double brooded in less than half of the years and we only found evidence of triple brooding in one year (1992).

The four major food types were green caterpillars, katydids, tree frogs, and grasshoppers. The caterpillars and katydids appear to be the preferred food, while the tree frogs and grasshoppers appear to be "fast food" that can be caught quickly to placate the young while the adults than go after the preferred food. Food resources vary greatly from year to year and have a significant impact on reproductive success. The number of eggs laid increased as the percent of katydids increased in the diet and the total number of young fledged per pair was dependent (nearly statistically significant) on the capture time of caterpillars, katydids, and all food, with shorter capture time leading to more young fledged.

The changing distribution of nesting pairs of Yellow-billed Cuckoos in the South Fork Kern River Valley raises several concerns. In 1985 radio-telemetry studies showed that cuckoos foraged preferentially in cottonwoods (Laymon and Halterman 1985). Over the past six years, as the cuckoos have moved farther west into the young willow forests, they have moved farther away from cottonwood dominated sites to the extent that in

1992 only six pairs had a significant number of cottonwoods within their home range. Several factors including distribution of food resources and predation could explain this shift to sites dominated by willows. The distribution of the preferred food, sphinx moth larva and katydids, is likely to differ from year to year. Areas that are flooded probably will have poor overwinter survival of sphinx moth larva and katydid eggs which winter underground. In the past two wet winters when the entire primary and part of the secondary floodplain was inundated, cuckoos have been foraging for sphinx moth larva on the restoration sites which were not flooded.

The abundance of secondary food such as tree frogs and grasshoppers may be very important in determining the actual nest site, because high densities of tree frogs or grasshoppers are needed to satiate the young and keep them from begging vigorously and attracting predators. The global decline of amphibians is certainly of concern and research on tree frogs has shown that increased ultraviolet radiation caused by the thinning of the ozone layer may be a cause for decline in this species (Blaustein et al. 1994). We have certainly seen fewer tree frogs in the field in the past five years of the study than we did in the first seven years. Even in the past two wet years we have seen little evidence of a recovery from the drought years of 1987 to 1992. The decline of this "fast food" could be detrimental to the long-term health of the cuckoo population here. Management of habitat to increase reproduction of tree frogs is an important consideration.

In order to explain and accurately predict Yellow-billed Cuckoo distribution and to understand the effects of food resources on the population further study is necessary. The study should combine monitoring the distribution and productivity of the cuckoos and the population dynamics and ecology of their main prey species, sphinx moth larva, katydids, and tree frogs. The radio-telemetry work conducted in 1985 should be repeated and expanded to include more individuals to determine home range size and characteristics, foraging habitat, and foraging patterns.

Nest Site Characteristics

The South Fork Wildlife Area, where we found 49 Yellow-billed Cuckoo nests, and the Kern River Preserve, where we found 38 cuckoo nests, are characterized by very different forest structure. The mean values for all measured vegetation structure variables, when the two sites are compared, are significantly different, with the exception of total forb cover (Table 6). This is a fortunate situation because if cuckoos are indeed selecting for certain vegetation structure, we have several ways to determine which variables are the most important.

Firstly, we can look at the ratio of the mean to the standard deviation. Low ratios (high mean and low standard deviation) indicate that some selection may be taking place. High ratios, especially where the standard deviation exceeds the mean, indicate that probably little or no selection is taking place. Variables relating to foliage cover above and around the nest consistently have the lowest ratios (all below 0.41, canopy cover under nest ratio = 0.08 which is the lowest ratio). The only other ratios that are below 0.5 are the mean tree height (0.29) and distance from nest to branch tip (0.43).

Secondly, we can look at whether or not the mean of cuckoo nests for a variable is significantly different than the random points in the two areas. Most variables are significantly different for both sites when cuckoo nests are compared to random points. Number of cottonwoods, basal area, and mean tree heights did not show significant differences on the Kern River Preserve and mean quadratic diameter did not show a significant difference on the South Fork Wildlife Area.

Lastly, we can look for significant differences between cuckoo nests on the two sites. Variables that vary significantly between sites most likely indicate that no selection has taken place (Table 9). Number of trees, number of willows, number of yellow willows, foliage volume, and mean quadratic diameter all are significantly different and may be good candidates for discarding from future consideration as important parameters that cuckoos use to select their nest sites.

When we have examined all the variables, canopy closure rises to the top as the most important nest site selection variable, while total ground cover, total forb cover, foliage volume, basal area, and mean tree height may be important, and nine have been discarded as not likely to be important. Canopy cover had a low mean to standard deviation ratio, was always highly selected for, and was very similar when compared between nests in the two areas. Ground cover had a moderate mean to deviation ratio, was always selected against, and was very similar when compared between the two areas. Forb cover had a moderate mean to deviation ratio, was always selected for, and was very similar when compared between the two areas. Foliage volume had a moderately high mean to deviation ratio, was always selected for, but was significantly higher on the Kern River Preserve when compared with the South Fork Wildlife Area. Basal area had a moderately high mean to deviation ratio, was selected for in the South Fork Wildlife Area but not the preserve, and was similar when compared between the two areas. Mean tree height had a moderately low mean to deviation ratio, was significantly higher on the South Fork Wildlife Area, and was very similar when compared between the two areas.

Histograms of the six variables also can tell us a great deal about habitat preference. Only one nest has canopy closure less than 40% and 65% canopy closure is the break point between few nests and many nests. This would indicate that sites with less than 40% canopy closure are unsuitable, sites from 40% to 65% are marginal to suitable and sites greater than 65% are optimal. Sites at the upper end of the scale (i.e. greater than 95% canopy closure) have fewer nest sites, but this may have more to do with availability than preference.

Percent forb cover and percent ground cover show no pattern with an equal number of nests showing high and low levels for these variables. This is an indication that these variables may not be important for cuckoo nest selection despite being indicated by our initial analysis as possibly important variables.

Cuckoos tend to chose nests at sites with a mean canopy height of 7m to 10m. This tree height may be optimal for the species. Sites with a mean canopy height from 4m to 7m are chosen less frequently but appear to be suitable. Sites with a mean canopy height of less than 4m are unsuitable. Sites with a mean canopy height of 10m to 15m are used less frequently, but appear to be suitable.

Cuckoos tend to choose nest sites that have a basal area of between $5m^2$/ha and $20m^2$/ha. Sites with $20m^2$/ha to $55m^2$/ha are not used as frequently but are suitable. Sites

with less than $5m^2$/ha and over $55m^2$/ha are seldom used by cuckoos and can be considered marginal.

Cuckoos seldom use sites that have a foliage volume of less than $20,000m^3$/ha and these sites are considered unsuitable. Most nest sites have foliage volume from $30,000m^3$/ha to $90,000m^3$/ha and these sites are considered optimal habitat. Sites with $20,000m^3$/ha to $30,000m^3$/ha and over $90,000m^3$/ha appear to be suitable.

These four variables, canopy closure, basal area, mean tree height, and foliage volume appear to be the most important variables in predicting Yellow-billed Cuckoo habitat suitability. In addition, at least one willow for a nest tree must be present at the site.

Management Recommendations

A management plan for yellow-billed cuckoos requires more than habitat preservation. All existing habitat should be preserved regardless of present habitat quality; however this probably will not insure the survival of the species in the state (Laymon and Halterman 1989). In addition, much riparian habitat restoration is needed before recovery of the cuckoo is complete, but how much and where? Any number that is derived is a result of a trade off between number of patches, patch size and patch isolation as pointed out by Shaffer (1985). Some basic tenets of conservation biology indicate that more patches are better than fewer, larger patches are better than smaller, and that less isolated patches are better than more isolated patches. In 1989 we recommend a target of at least 625 pairs of cuckoos for California (Laymon and Halterman 1989) and this still appears to be a reasonable target. The only population of cuckoos in California that has increased over the past 12 years is the Kern River population, but even here we are still 40% short of the minimum population objective of 25 pairs.

As predicted in our 1992 report heavy rain and snow in the winter of 1992-1993 nearly filled Isabella Reservoir in the spring and summer of 1993 to a level higher than any since 1986. The lake again nearly filled in 1995 and 1996 and is also very high in 1997. It is clear that to create a minimum population of 25 pairs with present reservoir management much more habitat needs to be created upstream out of the influence of the reservoir.

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LITERATURE CITED

Blaustein, A.R., P.D. Hoffman, D.G. Hokit, J.M. Kiesecker, S.C. Walls, and J.B. Hays. 1994. UV repair and resistance to solar UV-B in amphibian eggs: A link to population declines. Proc. Natl. Acad. Sci. 91:1791-1795.

Fleshman, C. and D.S. Kaufman. 1984. The South Fork (Kern River) Wildlife Area: Will the Commitment be Forgotten? pp. 482-494. In: R.E. Warner and K.M. Hendrix eds. California Riparian Systems: Ecology, Conservation, and Productive Management. Univ. of California, Berkeley, CA.

Laymon, S.A. and M.D. Halterman. 1985. Yellow-billed Cuckoos in the Kern River Valley: 1985 population, habitat use, and management recommendations. Unpublished manuscript prepared for the Nature Conservancy, Kern River Preserve. P.O. Box 1662 Weldon, CA 93283.

Laymon, S.A. and M.D. Halterman. 1986. Nesting ecology of the Yellow-billed Cuckoo on the Kern River: 1986. Unpublished manuscript prepared for The Nature Conservancy and California Department of Fish and Game. Non-Game Wildlife Investigations, Endangered Species Section 1416 9th Street Sacramento, CA 95814.

Laymon, S.A. 1987. Yellow-billed Cuckoos and reforestation on the Kern River Preserve. Administrative Report to The Nature Conservancy.

Laymon, S.A., M.D. Halterman and M.J. Whitfield. 1987. Nesting ecology of the Yellow-billed Cuckoo on the Kern River: 1987. Unpublished manuscript prepared for The Nature Conservancy and California Department of Fish and Game. Non-Game Wildlife Investigations, Endangered Species Section, 1416 9th Street Sacramento, CA 95814.

Laymon, S.A. and M.J Whitfield. 1988. Nesting ecology of the Yellow-billed on the Kern River: 1988. Unpublished manuscript prepared for The Nature Conservancy and California Department of Fish and Game. Non-Game Wildlife Investigations, Endangered Species Section, 1416 9th Street, Sacramento, CA 95814.

Laymon, S.A., M.D. Halterman and T. Gallion. 1989. Nesting ecology of the Yellow-billed on the Kern River: 1988. Unpublished manuscript prepared for The Nature Conservancy and California Department of Fish and Game. Non-Game Wildlife Investigations, Endangered Species Section, 1416 9th Street, Sacramento, CA 95814.

Laymon, S.A., M.D. Halterman, A.E. Launer, and D.D. Murphy. 1990. 1990 Distribution and Habitat Requirements of the Yellow-billed Cuckoo in California. Unpublished Draft Admin. Rept. prepared for The Nature Conservancy. Center for Conservation Biology,

Dept. of Biol. Sci., Stanford University, Stanford, CA 94305 and Kern River Research Center, P.O. Box 990, Weldon, CA 93283.

Laymon, S.A. 1991. Breeding Status of the Yellow-billed Cuckoo in the South Fork Kern River Valley, Kern County, California: Summer 1991. Administrative Report, Kern River Research Center, P.O. Box 990, Weldon, CA 93283.

Laymon, S.A., P.L Williams, and M.D. Halterman. 1993. Breeding Status of the Yellow-billed Cuckoo in the South Fork Kern River Valley, Kern County, California: Summer 1992. Administrative Report, Prepared for USDA Forest Service, Sequoia National Forest, Cannell Meadow Ranger District.

Shaffer, M.L. 1985. The metapopulation and species conservation: the special case of the northern spotted owl. Pp. 86-99 in R.J. Gutierrez and A.B. Carey, eds., Ecology and Management of the Spotted Owl in the Pacific Northwest. USDA For. Serv. Gen. Tech. Rep. PNW-185.

Table 1. Location of Yellow-billed Cuckoo Nesting Pairs on the South Fork Kern River 1985 to 1996.

Year	Number of Pairs	Kern River Preserve	South Fork Wildlife Area	Isabella Reservoir
1985	9	7	2	0
1986	9	8	1	0
1987	3	2	1	0
1988	3	1	2	0
1989	6	2	4	0
1990	2	0	2	0
1991	12	1	8	3
1992	24	4	10	10
1993	19	8	11	0
1994	19	8	11	0
1995	13	8	5	0
1996	14	11	3	0
Average	11.1	5.0	5.0	1.1
Average 1985-1990	5.3	3.3	2.0	0.0
Average 1985-1986	16.8	6.7	8.0	2.2

Table 2. Estimated extent of suitable Yellow-billed Cuckoo nesting habitat available at South Fork Kern River 1985 to 1996.

Year	Total Habitat (ha)	Kern Preserve Habitat (ha)	South Fork Wildlife Habitat (ha)	Isabella Reservoir Draw-Down Zone (ha)
1985	292	212	80	0
1986	292	212	80	0
1987	342	212	130	0
1988	392	212	180	0
1989	452	222	230	0
1990	522	242	280	0
1991	722	242	380	100
1992	854	274	380	200
1993	542	312	230	0
1994	700	320	380	0
1995	508	328	180	0
1996	527	347	180	0

Table 3. Comparison of Yellow-billed Cuckoo nesting success on the South Fork Kern River, 1985 to 1996.

Year	Number of Pairs	Nests Located	Successful Nests	Total Young Produced
1985	9	8	8	23
1986	9	4	3	12
1987	3	2	2	6
1988	3	3	3	6
1989	6	3	3	12
1990	2	1	1	4
1991	12	6	5	28
1992	24	23	19	83
1993	19	14	14	60
1994	19	11	11	48
1995	13	8	6	23
1996	14	12	7	20
Average	11.1	8.0	6.8	28
Average 1985-1990	5.3	3.7	3.3	11
Average 1991-1996	16.8	12.3	10.3	45

Table 4a. Comparison of Yellow-billed Cuckoo nesting success on the South Fork Kern River, 1985 to 1996. Mean ± SE (N).

Year	Clutch Size	Number Hatched	Number Fledged	% Successful	% Hatched	% Fledged
1985	3.00±0.19(8)	2.75±0.25(8)	2.63±0.26(8)	100%(8)	92%(8)	88%(8)
1986	3.00±0.35(4)	2.50±0.29(4)	1.25±0.48(4)	75%(4)	83%(4)	42%(4)
1987	2.50±0.50(2)	2.50±0.50(2)	2.00±0.00(2)	100%(2)	80%(2)	80%(2)
1988	2.67±0.33(3)	2.00±0.58(3)	2.00±0.58(3)	100%(3)	75%(3)	75%(3)
1989	2.33±0.33(3)	2.33±0.33(3)	2.33±0.33(3)	100%(3)	100%(3)	100%(3)
1990	2.00±0.00(1)	2.00±0.00(1)	2.00±0.00(1)	100%(1)	100%(1)	100%(1)
1991	2.67±0.21(6)	2.67±0.21(6)	2.33±0.49(6)	83%(6)	100%(6)	87%(6)
1992	3.35±0.21(23)	2.87±0.24(23)	2.39±0.26(23)	83%(23)	86%(23)	71%(23
1993	2.83±0.21(12)	2.58±0.23(12)	2.31±0.26(13)	100%(14)	91%(12)	82%(12)
1994	3.00±0.13(11)	2.36±0.20(11)	2.45±0.21(11)	100%(11)	79%(11)	82%(11)
1995	2.50±0.19(8)	2.38±0.26(8)	1.75±0.45(8)	75%(8)	95%(8)	70%(8)
1996	3.00±0.19(11)	2.09±0.34(11)	1.27±0.33(11)	64%(11)	70%(11)	42%(11)
Avg.	2.95±0.08(92)	2.53±0.09(92)	2.14±0.11(93)	87%(94)	86%(92)	73%(92)
Avg. 85-90	2.76±0.13(21)	2.48±0.15(21)	2.14±0.19(21)	95%(21)	90%(21)	78%(21)
Avg. 91-96	3.00±0.09(71)	2.55±0.11(71)	2.14±0.14(71)	87%(71)	85%(71)	71%(71)

Table 4b. Yellow-billed Cuckoo nesting success and nest tree characteristics at the South Fork Kern River 1985 to 1996.

Variable	Number of Nests	Mean	SD	Min	Max
First Egg Date	90	8 Jul.	12.9	6 Jun.	5 Aug.
Nest Tree Height (m)	95	4.8	3.5	1.3	13.0
Nest Tree DBH (cm)	94	25.4	18.9	3.0	90.0
Nest Height (m)	95	4.8	3.0	1.3	13.0
Distance from Nest to Tip of Branch (m)	95	1.4	0.6	0.0	3.0
Distance from Nest to Trunk of Tree (m)	95	2.7	3.1	0.0	12.0
Distance to Foliage Above Nest (cm)	94	0.2	0.3	0.0	1.5
Foliage Cover Above Nest (%)	95	93.4	15.1	0.0	100.0
Distance from Nest Tree to Forest Edge (m)	95	61.5	79.1	1.0	300.0
Distance from Nest Tree to Nearest Water (m)	95	310.1	405.5	0.0	1500.0

Table 5. Vegetation Survey Results Taken on 0.1 acre Plot Centered on Yellow-billed Cuckoo Nest Trees from 1985 to 1996.

Variable	Number of Nests	Mean	SD	Min	Max
Total Canopy Cover (%)	85	74.1.	15.6	16.5	98.0
Canopy Cover above Nest (%) (Taken at 2 Locations)	75	96.8	7.3	63.0	100.0
Canopy Cover 5m from Nest (%) (Taken at 4 Locations)	75	75.1	18.1	17.5	100.0
Canopy Cover 10m from Nest (%) (Taken at 4 Locations)	75	63.8	26.1	0.0	100.0
Total Ground Cover (%)	83	58.4	35.6	0.0	100.0
Total Bare Ground (%)	86	23.6	27.0	0.0	98.0
Total Grass Cover (%)	83	17.3	24.8	0.0	100.0
Total Forb Cover (%)	85	51.2	33.1	0.0	100.0
Total Shrub Cover (%)	85	3.5	8.4	0.0	50.0
Number of Trees/ha	95	826.5	955.5	0.0	4446.0
Number of Willows/ha	95	721.4	844.5	0.0	3334.5
Number of Yellow Willow/ha	87	562.7	789.7	0.0	3334.5
Number of Red Willow/ha	87	157.9	389.6	0.0	2840.5
Number of Cottonwood/ha	95	85.1	471.0	0.0	4322.5
Foliage Volume (M^3/ha)	85	110,686	95,908	11,978	728,374
Basal Area (m^2/ha)	75	19.6	18.4	4.3	155.6
Mean Quadratic DBH (cm)	85	22.9	13.5	5.8	85.3
Mean Height of Trees (m)	83	9.1	2.6	4.4	19.5

Table 6. Comparison of Habitat Measurements at 160 Random Points on the Kern River Preserve (KRP) with those at 80 Random Point on the South Fork Wildlife Area (SFWA).

Variable	SFWA Random Points	KRP Random Points	t-value	p-value
Total Canopy Cover (%)	31.0	57.2	6.72	0.00
Total Ground Cover (%)	86.4	68.7	4.64	0.00
Total Bare Ground (%)	9.6	15.2	2.22	0.03
Total Grass Cover (%)	56.5	41.5	3.60	0.00
Total Forb Cover (%)	33.7	34.9	0.32	n.s.
Total Shrub Cover (%)	0.0	14.4	7.17	0.00
Number of Trees/ha	676.3	266.1	4.80	0.00
Number of Willows/ha	676.3	119.9	7.92	0.00
Number of Yellow Willow/ha	676.3	35.4	10.05	0.00
Number of Red Willow/ha	0.0	83.7	3.08	0.02
Number of Cottonwood/ha	0.0	141.4	2.96	0.00
Foliage Volume (M^3/ha)	39,579	62,545	2.83	0.01
Basal Area (m^2/ha)	10.0	34.0	3.14	0.00
Mean Quadratic DBH (cm)	14.8	51.5	7.53	0.00
Mean Height of Trees (m)	6.4	8.5	3.84	0.00

Table 7. Comparison of Habitat Measurements at 38 Yellow-billed Cuckoo Nests with those at 160 Random Point on the Kern River Preserve.

Variable	Cuckoo Nests	Random Points	t-value	p-value
Total Canopy Cover (%)	77.2	57.2	3.91	0.00
Total Ground Cover (%)	56.9	68.7	2.01	0.05
Total Bare Ground (%)	26.5	15.2	2.88	0.00
Total Grass Cover (%)	18.7	41.5	4.35	0.00
Total Forb Cover (%)	49.5	34.9	2.98	0.00
Total Shrub Cover (%)	5.1	14.4	2.99	0.00
Number of Trees/ha	629.7	266.1	3.24	0.00
Number of Willows/ha	370.8	119.9	4.24	0.00
Number of Yellow Willow/ha	87.3	35.4	2.02	0.04
Number of Red Willow/ha	204.7	83.7	2.43	0.02
Number of Cottonwood/ha	218.2	141.4	0.87	n.s.
Foliage Volume (M^3/ha)	138,554	62,545	5.48	0.00
Basal Area (m^2/ha)	24.1	34.0	0.77	n.s.
Mean Quadratic DBH (cm)	29.8	51.5	2.99	0.00
Mean Height of Trees (m)	9.4	8.5	1.19	n.s.

Table 8. Comparison of Habitat Measurements at 49 Yellow-billed Cuckoo Nests with those at 80 Random Point on the South Fork Wildlife Area.

Variable	Cuckoo Nests	Random Points	t-value	p-value
Total Canopy Cover (%)	71.7	31.0	10.11	0.00
Total Ground Cover (%)	56.5	86.4	5.32	0.00
Total Bare Ground (%)	20.9	9.6	3.10	0.00
Total Grass Cover (%)	14.8	56.5	8.04	0.00
Total Forb Cover (%)	52.4	33.7	3.42	0.00
Total Shrub Cover (%)	2.3	0.0	2.97	0.00
Number of Trees/ha	1139.8	676.3	2.97	0.00
Number of Willows/ha	1126.2	676.3	2.91	0.00
Number of Yellow Willow/ha	989.6	676.3	2.08	0.04
Number of Red Willow/ha	170.3	0.0	3.11	0.00
Number of Cottonwood/ha	13.6	0.0	2.06	0.04
Foliage Volume (M^3/ha)	90,212	39,579	4.61	0.00
Basal Area (m^2/ha)	17.0	10.0	3.12	0.00
Mean Quadratic DBH (cm)	17.9	14.8	1.77	n.s.
Mean Height of Trees (m)	9.0	6.4	4.65	0.00

Table 9. Comparison of Habitat Measurements at 49 Yellow-billed Cuckoo Nests in the South Fork Wildlife Area with 38 Cuckoo nests on the Kern River Preserve.

Variable	SFWA Cuckoo Nests	KRP Cuckoo Nests	t-value	p-value
Total Canopy Cover (%)	71.7	77.2	1.63	n.s.
Total Ground Cover (%)	56.5	56.9	0.34	n.s
Total Bare Ground (%)	20.9	26.5	0.96	n.s
Total Grass Cover (%)	14.8	18.7	0.72	n.s
Total Forb Cover (%)	52.4	49.5	0.40	n.s
Total Shrub Cover (%)	2.3	5.1	1.53	n.s.
Number of Trees/ha	1139.8	629.7	2.48	0.01
Number of Willows/ha	1126.2	370.8	4.46	0.00
Number of Yellow Willow/ha	989.6	87.3	5.46	0.00
Number of Red Willow/ha	170.3	204.7	0.35	n.s.
Number of Cottonwood/ha	13.6	218.2	1.85	n.s.
Foliage Volume (M^3/ha)	90,212	138,554	2.36	0.02
Basal Area (m^2/ha)	17.0	24.1	1.63	n.s.
Mean Quadratic DBH (cm)	17.9	29.8	4.42	0.00
Mean Height of Trees (m)	9.0	9.4	0.77	n.s.

Table 10. Comparison of Food Brought to Nestlings in Yellow-billed Cuckoo Nests in the South Fork Kern River from 1985 to 1996.

Nest	Green Caterpillars	Katydid	Tree Frog	Grasshopper	Other	Nests Observed	Sample Size
1985	34.6%	28.7%	20.0%	14.5%	2.2%	9	271
1986	20.0%	24.9%	42.7%	10.8%	1.6%	4	410
1987	61.5%	13.4%	19.8%	4.6%	0.7%	2	247
1988	38.5%	17.1%	39.3%	4.4%	0.7%	2	117
1989	50.4%	26.4%	3.7%	17.1%	2.4%	3	375
1992	27.8%	43.0%	21.6%	6.9%	0.7%	5	684
1993	58.3%	15.4%	18.3%	5.8%	2.1%	3	240
1995	64.5%	5.3%	25.0%	5.3%	0.0%	2	76
Total	44.9%	21.8%	23.8%	8.7%	1.3%	30	2420

Table 11. Comparison of Size of Food Brought to Nestlings in Yellow-billed Cuckoo Nests in the South Fork Kern River from 1985 to 1996.

Nest	Green Caterpillars	Katydid	Tree Frog	Nests Observed	Sample Size
1985	5.5 cm	5.5 cm	3.3 cm	9	271
1986	4.8 cm	4.8 cm	3.3 cm	4	410
1987	4.5 cm	3.5 cm	3.3 cm	2	247
1988	3.8 cm	4.0 cm	no data	2	117
1989	4.5 cm	4.0 cm	3.3 cm	3	375
1992	4.8 cm	3.8 cm	3.7 cm	5	684
1993	5.2 cm	4.0 cm	3.6 cm	3	240
1995	5.4 cm	4.7 cm	4.1 cm	2	76
Total	4.8 cm	4.3 cm	3.5 cm	30	2420

Table 12. Comparison of Length of Capture Time for Food Brought to Nestlings in Yellow-billed Cuckoo Nests in the South Fork Kern River from 1985 to 1996.

Nest	Green Caterpillars	Katydid	Tree Frog	Nests Observed	Sample Size
1985	35.4 min	28.3 min	33.2 min	9	271
1986	71.1 min	60.8 min	30.8 min	4	410
1987	53.7 min	40.5 min	41.7 min	2	247
1988	82.4 min	60.7 min	30.7 min	2	117
1989	38.7 min	35.0 min	38.9 min	3	375
1992	21.6 min	16.5 min	13.0 min	5	684
1993	21.3 min	16.2 min	24.9 min	3	240
1995	27.2 min	12.0 min	18.5 min	2	76
Total	43.9 min	33.8 min	29.0 min	30	2420

Figure 1. Location of Yellow-billed Cuckoo Home Ranges on the South Fork Kern River, 1985 and 1986.

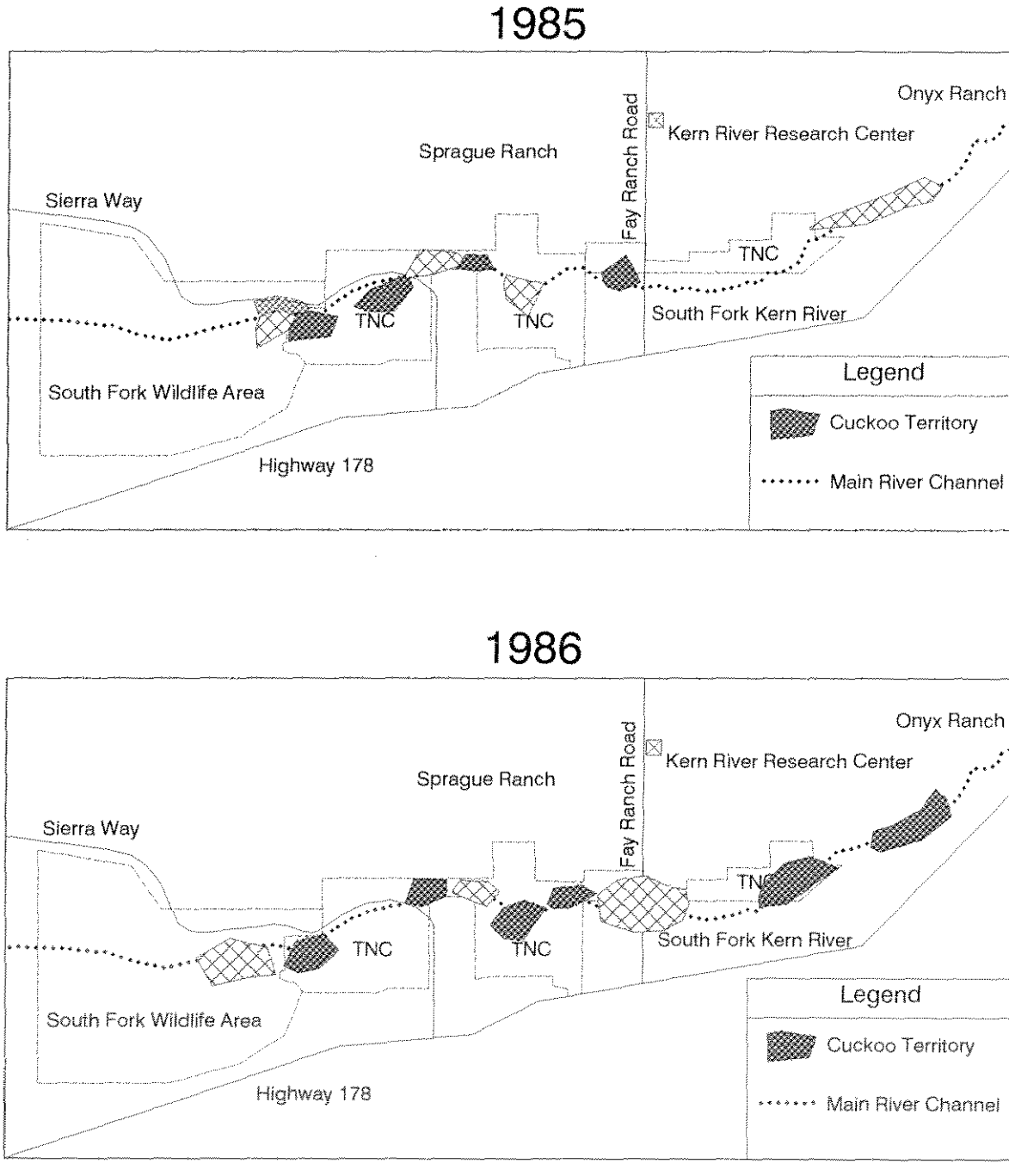

Figure 2. Location of Yellow-billed Cuckoo Home Ranges on the South Fork Kern River, 1987 and 1988.

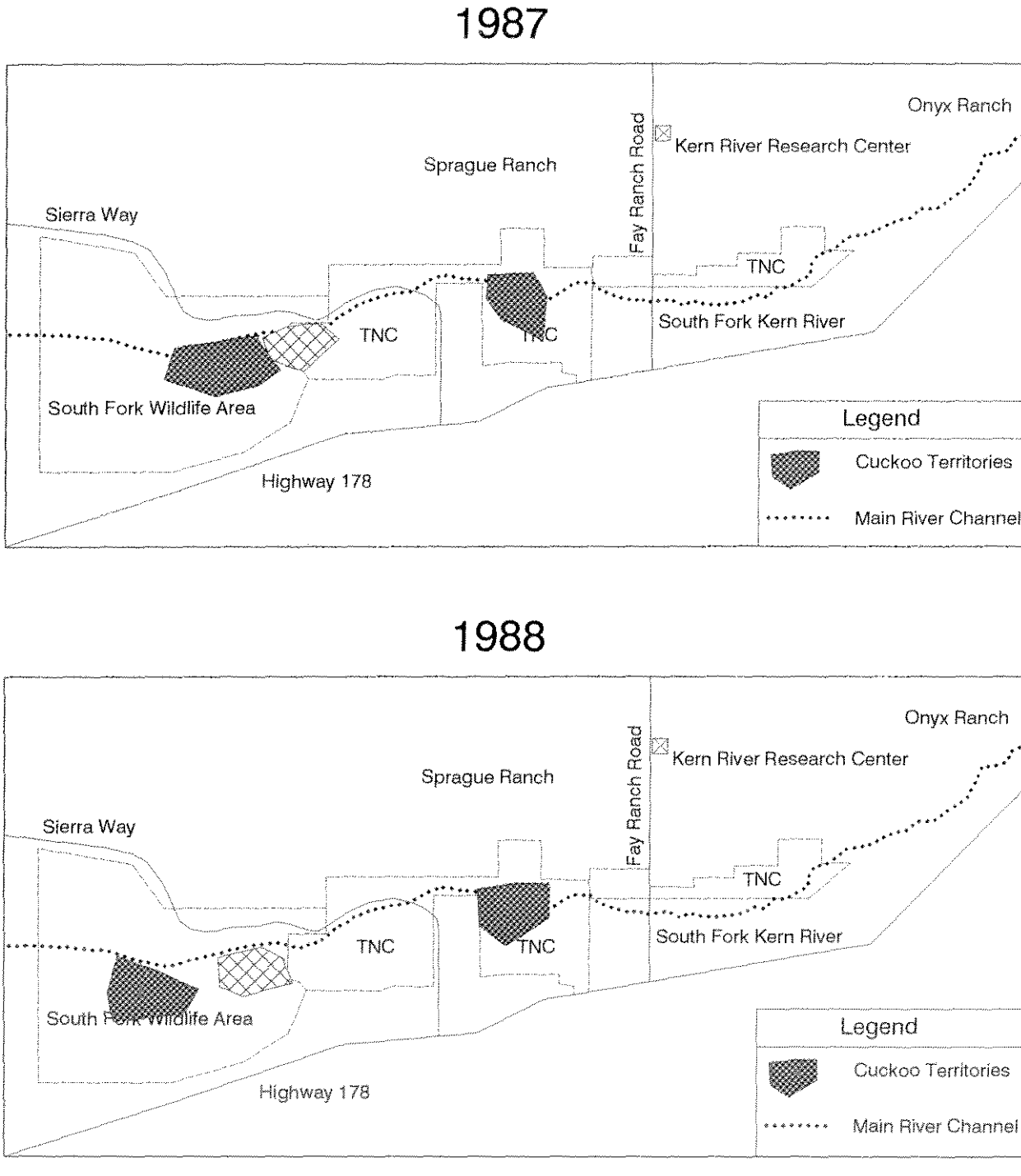

Figure 3. Location of Yellow-billed Cuckoo home ranges on the South Fork Kern River, 1989 and 1990.

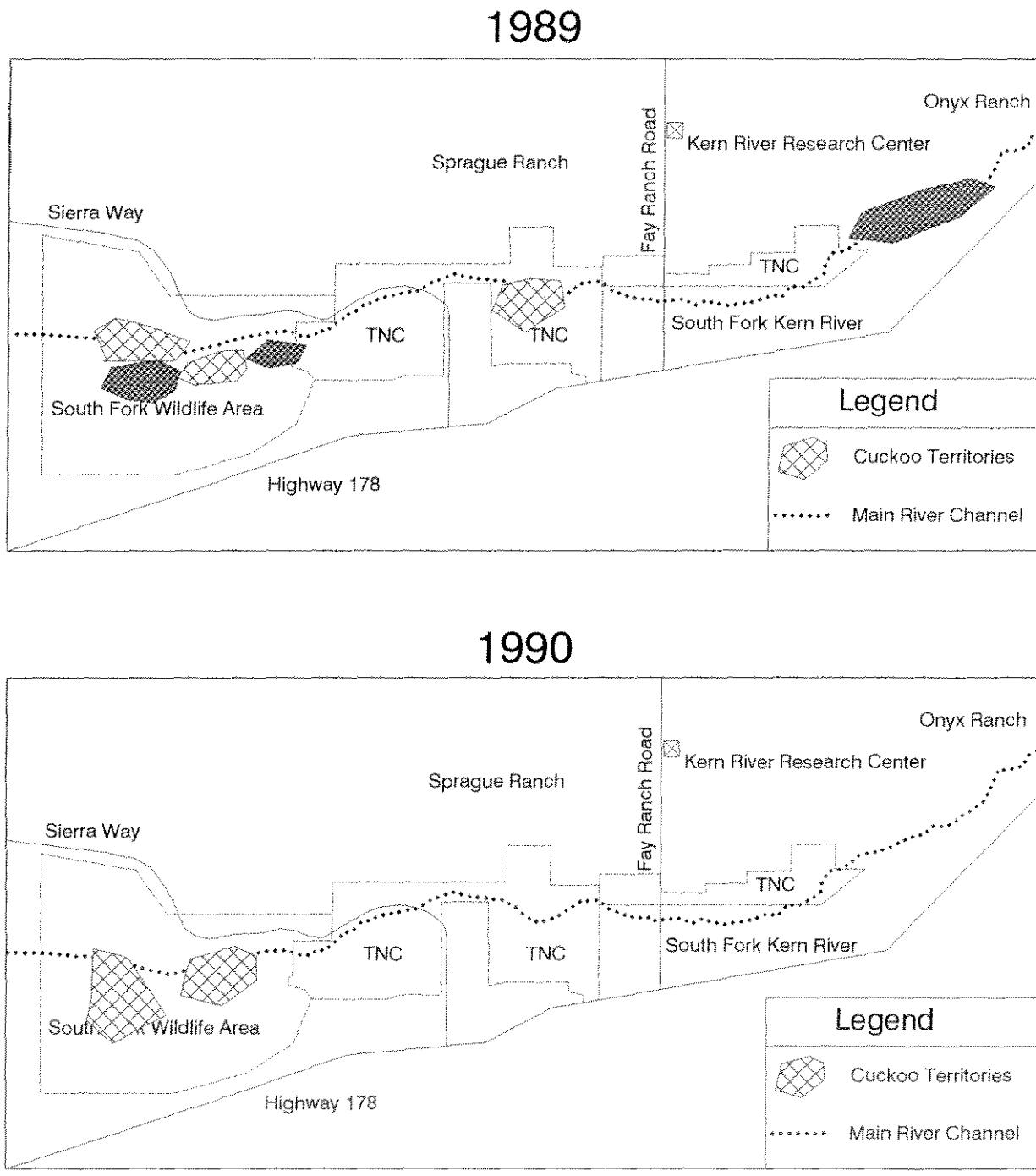

Figure 4. Map of Yellow-billed Cuckoo Territories and Nest Locations in the South Fork Kern River Valley, Summer 1991.

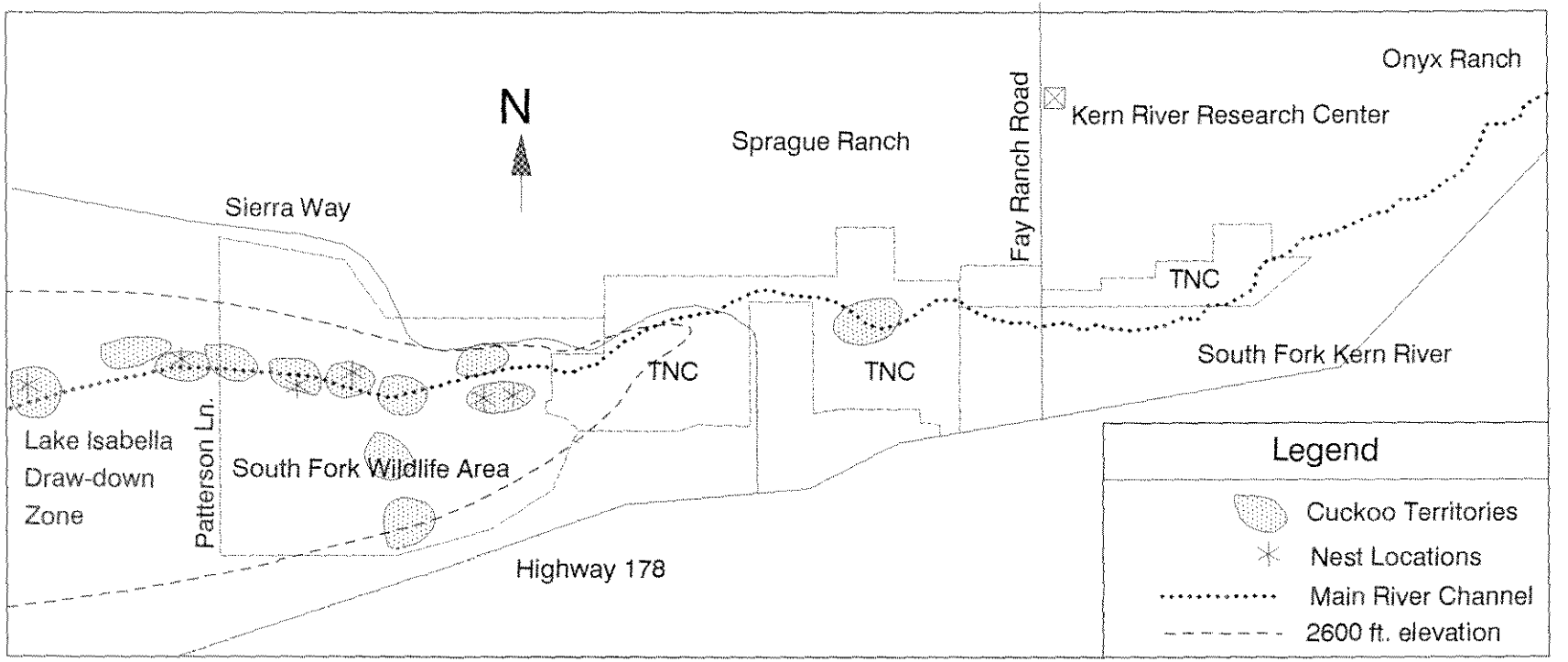

Figure 5. Map of Yellow-billed Cuckoo Territories and Nest Locations in the South Fork Kern River Valley, Summer 1992.

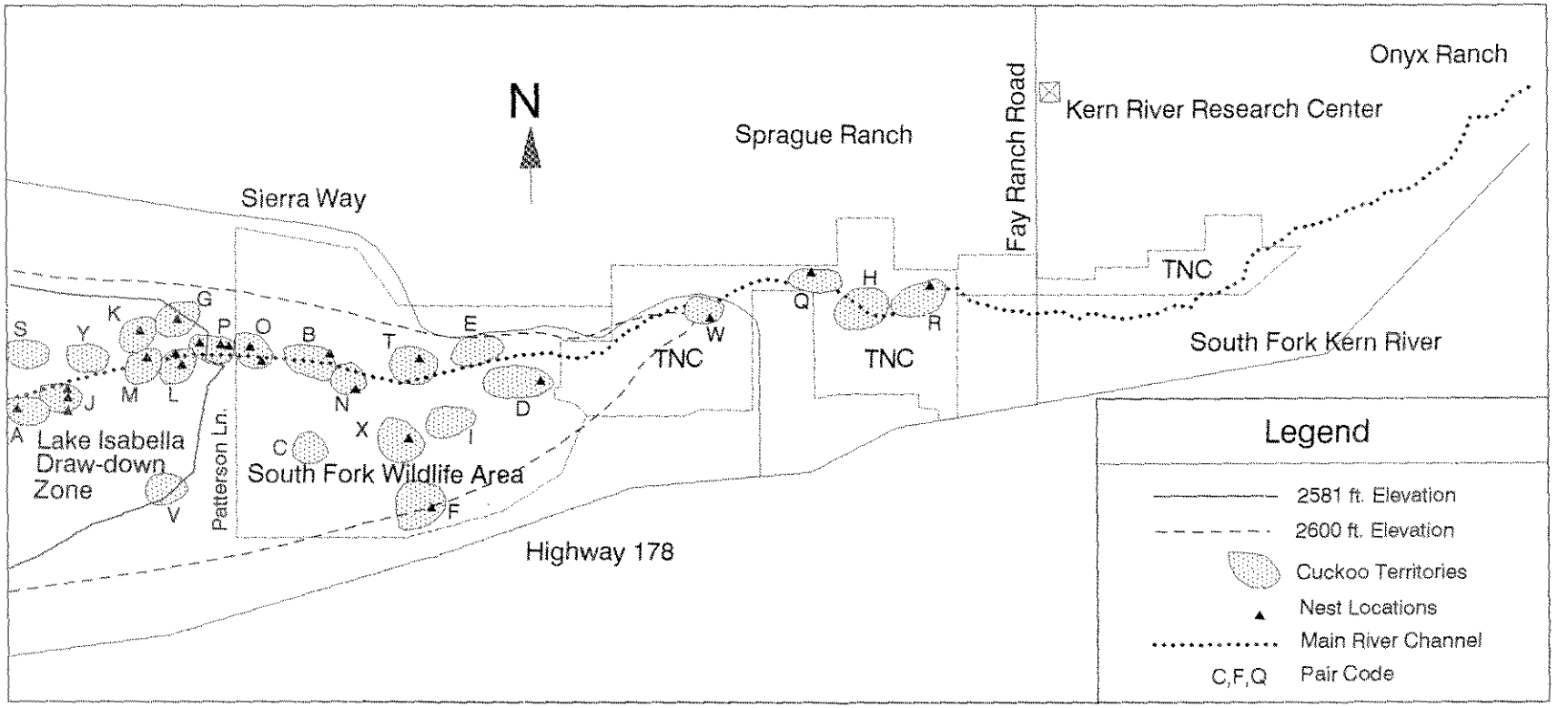

Figure 6. Map of Yellow-billed Cuckoo Territories and Nest Locations in the South Fork Kern River Valley, Summer 1993.

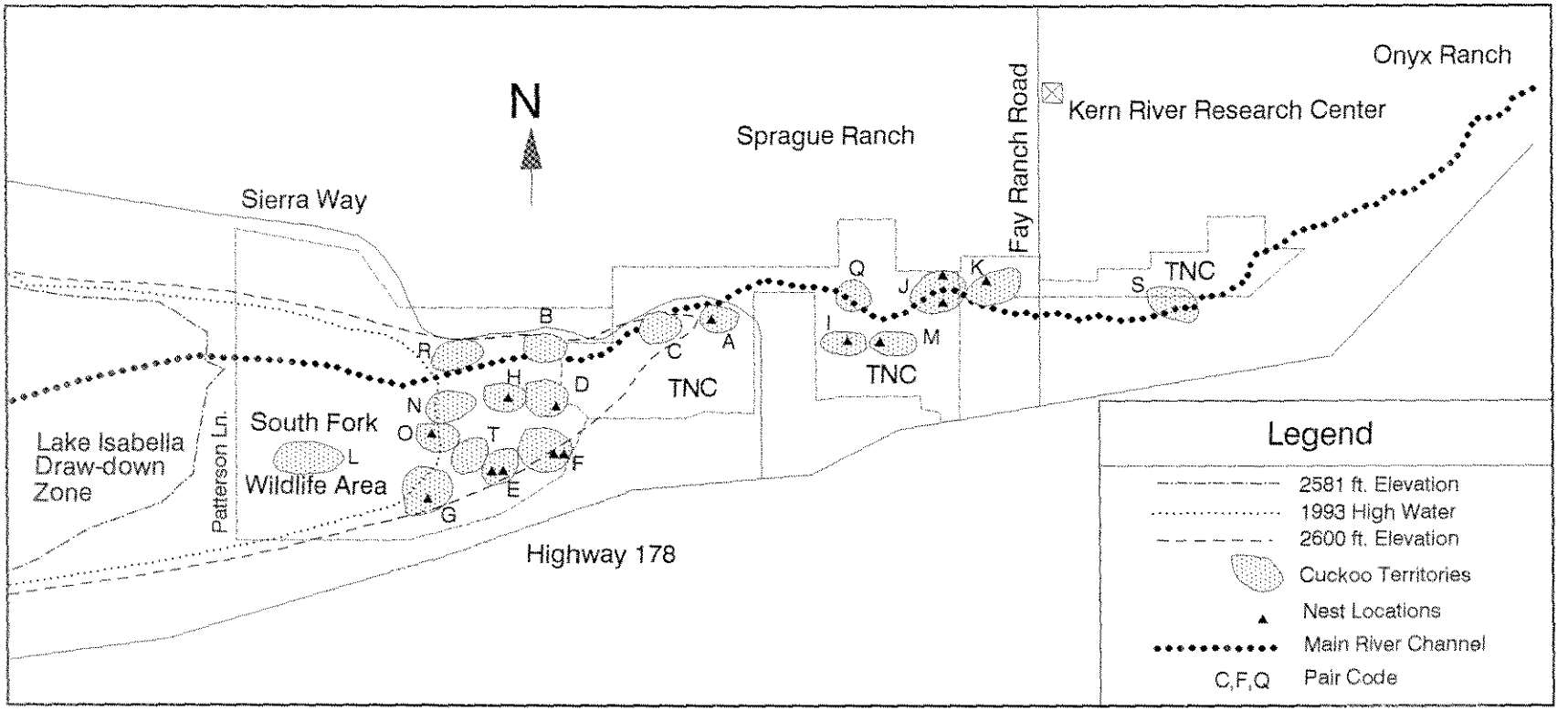

Figure 7. Map of Yellow-billed Cuckoo Territories and Nest Locations in the South Fork Kern River Valley, Summer 1994.

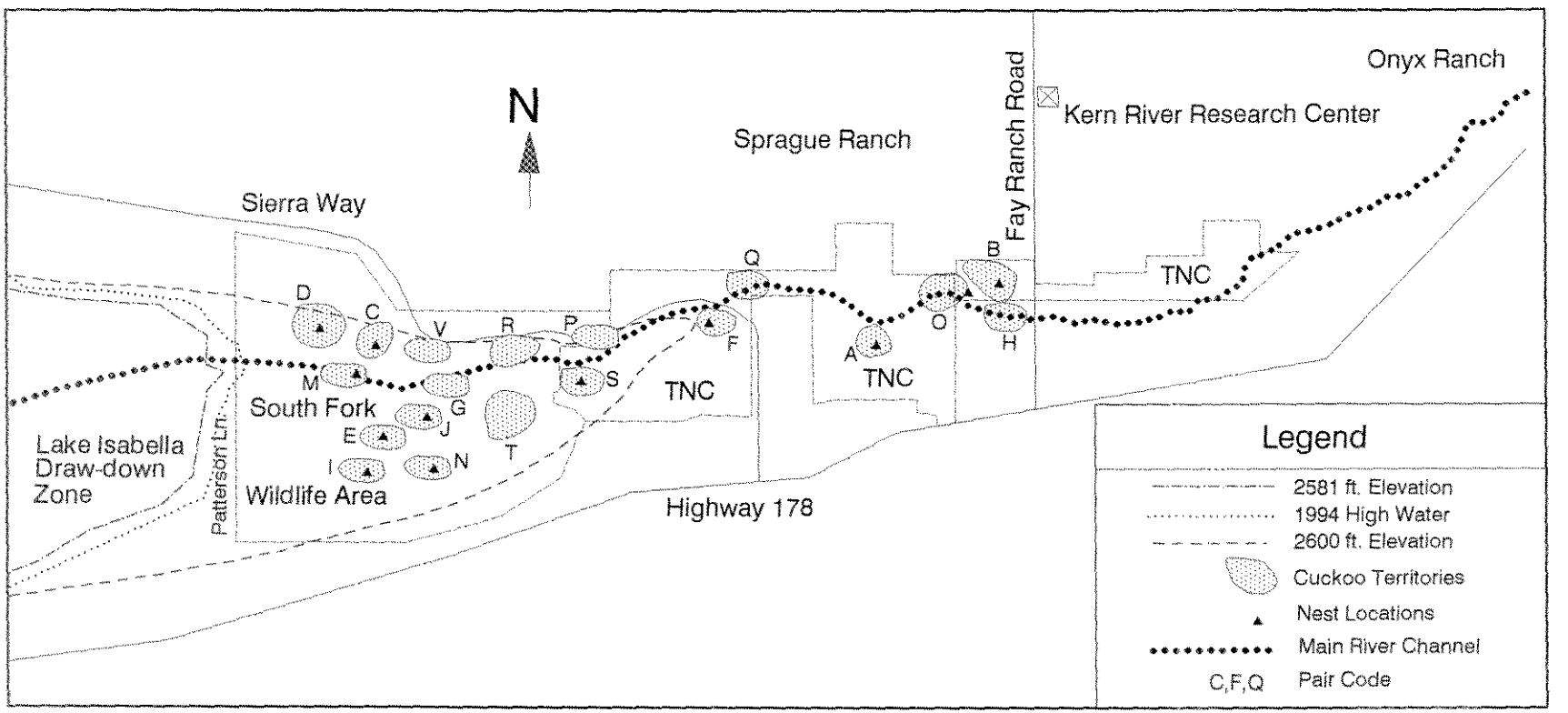

Figure 8. Map of Yellow-billed Cuckoo Territories and Nest Locations in the South Fork Kern River Valley, Summer 1995.

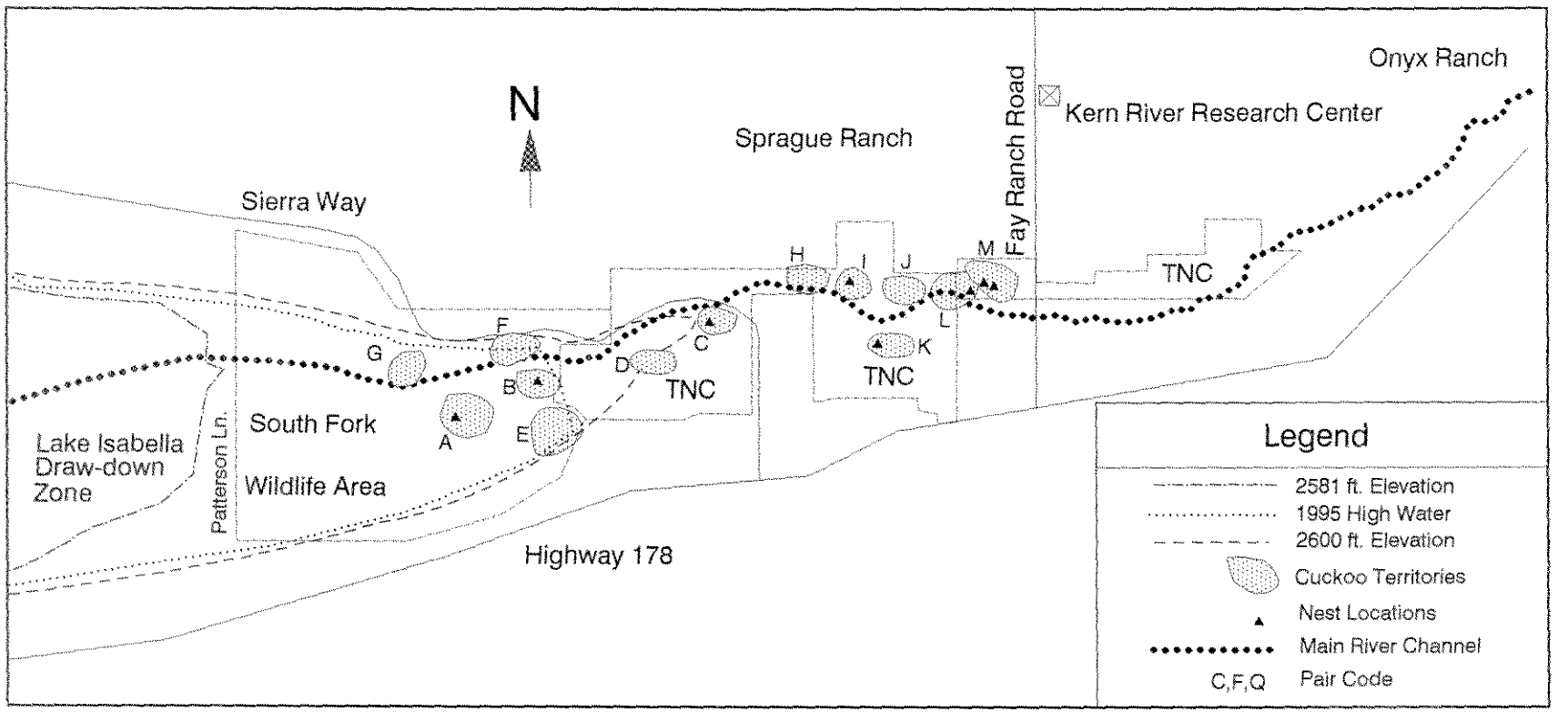

Figure 9. Map of Yellow-billed Cuckoo Territories and Nest Locations in the South Fork Kern River Valley, Summer 1996.